Claims

1.0 What I claim as my invention is as following:

1.1 Energy conservation flywheel with variable moment of inertia (ECF-VMI) principal of operation.

"ECF-VMI" will start to rotate after it receives initial spin, thru flexible or a detachable coupling (fc/dc), from any driving device. This driving device will be turned off and/or detached then the sum of moments of external forces acting about the axis of "ECF-VMI" is zero.

Initial centrifugal forces, created by rotation, will cause movable steel weights (mass) on sliding rods to start moving outward; mass moment of inertia of flywheel (fw) will start increasing while rotation and centrifugal forces will start decreasing. When centrifugal forces become equal to a steel spring (ssp) force stretched for a lent of weights travel, then at this point centrifugal forces and spring force will be in balance. After some time, rotation will start decreasing (so centrifugal forces & kinetic energy) therefore a spring force becomes greater than centrifugal forces hence will start to retract weights (mass moment of inertia is decreasing). When weights are retracted then rotation will start increasing while mass moment of inertia is decreasing (conservation of angular momentum), also centrifugal forces will start increasing thus pulling weights out. When centrifugal forces become equal to a spring (ssp) force again and after some time, rotation starts to decrease thus centrifugal forces start to decrease hence a spring (ssp) will start to retract weights inward. This increases rotation (conservation of angular momentum); increased rotation will cause increase of centrifugal forces (also kinetic energy) and so on process will continue to cycle. Now driving device can be turned or coupled on in order to use flywheel (fw) stored energy.

This device rotates in horizontal plane. Friction losses are neglected in the above explanation.

More efficient operation of this flywheel would be if magnetic bearings are used (instead machine bearings) and if it operates in a vacuum canister!

There is no size/mass limit of this device, and one can only imagine what magnitude of centrifugal forces, angular momentum and kinetic energy may be achieved with a right size and rotation.

Movable weights (mass) may be of different shape than a sphere.

1.2 Energy conservation flywheel with variable moment of inertia (ECF-VMI) device.

1.3 Flywheel (FW) in the shape of a top which consists of a disk and a hollow shaft. Disk is of rigid material (steel); has four bored (fine machined) 90 deg. apart holes (cylinders) from circumference toward center; also has four square cut-offs near the center equally spaced. Hollow shaft is of rigid material (steel) and it has four, perpendicular to a shaft axis, holes (fine machined). These holes have inlet/outlet bells.

1.4 The following assembly: a weight (mass), a fine machined piston/rod treaded on one side and has axial hole and two radial holes (treaded) on other side. Steel cables and cables clip, rotating spring mechanism (bearing and a tension bolt/nut).

Description Of Operation Of The Energy Conservation Flywheel With Variable Moment Of Inertia Model "ECF-VMI-01" (Shown On Drawings) And Is In Production.

"ECF-VMI-01" will start to rotate after it receives initial spin, thru a flexible coupling and/or a detachable clutch (fc/dc), from any driving device. This driving device will be turned off and/or detached so then the sum of moments of external forces about the axis is zero. Let the initial (or point #1) spin be 52 rad/s (496 rpm), then mass moment of inertia will be 0.2116 (slug-ft^2), centrifugal forces created by rotation and acting on spheres (ss/r) will be 750.4 lbs at this point. This will cause steel spheres/rods (ss/r) to start moving outward, mass moment of inertia will start increasing (at final or point #2 will be 0.3208 slug-ft^2), rotation/centrifugal forces will be decreasing (34.3 rad/s or 327 rpm at point#2); kinetic energy will be decreasing also. At point #2 centrifugal forces (431.2 lbs) will become equal to the steel spring (ssp) force (431.2 lbs) stretched for a lent of the spheres/rods (ss/r) travel. Therefore centrifugal forces and a spring force will be in balance. Further rotation decreasing (so centrifugal forces) will cause spheres (ss/r) to start retracting under the spring (ssp) force. When this happen, rotation will start to increase (conservation of angular momentum) hence centrifugal forces will increase (kinetic energy too) also; (ss/r) will be moving outward until centrifugal forces become equal to the spring (ssp) force. Again, when rotation starts to decrease centrifugal forces will start to decrease hence the spring (ssp) will start to retract steel spheres (ss/r) in and thus mass moment of inertia will decrease but rotation will start increasing (conservation of angular momentum). Increased rotation will cause increase of centrifugal forces (also kinetic energy); the steal spheres (ss/r) will start moving outward and so on process will continue to cycle.

Now driven device can be turned or coupled on in order to use "ECF-VMI-01" stored kinetic energy.

This device rotates in horizontal plane.

Friction loses are neglected in the above explanation.

Sample Calculation of the Above Description of ECF-VMI-01

Steel Sphere (ss)

Diameter D=3"; Radius r=1.5"; Steel density δ=490 lbs/ft^3

Sphere volume V= $4/3\pi\ r^3 = 4/3 x\pi\ \ x\ 1.5^3 = 14.14$ in^3 = 0.0082 ft^3

Sphere weight $w = V\delta = 0.0082 \times 490 = 4.0$ lbs

Sphere mass $m = w/g = 4.0/32.2 = 0.124$ slugs, where

$g = 32.2$ ft/s^2; slug = (lbs s^2 /ft)

Mass moment of inertia of 'ss'

$Io = 2/5mr^2$ (slug-ft^2) centroidal; $Io = 2/5 \times 0.124 \times (1.5/12)^2 = 0.000775$ (slug-ft^2)

Sphere is 6.5" away from axis initially, and then mass moment of inertia about axis (z) is,

$Izi = Io + mxi^2 = 0.000775 + 0.124 \times (6.5/12)^2 = 0.0372$ (slug-ft^2)

Sphere is moving outward, farthest from axis (z) is 8.5", and then mass moment of inertia is,

$Izf = Io + mxf^2 = 0.000775 + 0.124 \times (8.5/12)^2 = 0.063$ (slug-ft^2)

There are 4 spheres, therefore

$Izi\ (4) = 4 \times 0.0372 = 0.149$ (slug-ft^2)

$Izf\ (4) = 4 \times 0.063 = 0.252$ (slug-ft^2)

Wheel/Disk (w/d)

Diameter D =10"; Radius r = 5"; Thickness t = 1"

Solid disk volume: $V = r^2\pi\ \ t\ (ft^3)$; $V = (5/12)^2 \text{ x}\pi\ \text{ x } (1/12) = 0.04545\ (ft^3)$

Weight of solid disk: $W = V\ \delta = 0.04545 \text{ x } 490 = 22.27$ (lbs)

Mass of solid disk: $m = W/g = 22.27 / 32.3 = 0.692$ (slug)

Mass moment of inertia of solid disk: $Iy = Iz= ½\ m\ r^2 = ½ \text{ x } 0.692 \text{ x } (5/12)^2 = 0.06$ (slug-ft^2)

Square openings

$a = 1"; t = 1"; W = V\ \delta = (1/12)^2 \text{ x } (1/12)^2 \text{ x } 490 = 0.284$ (lbs); Mass, $m = 0.284/32.2 = 0.0088$ (slug)

This opening is a negative weight (only air is there)! Also it is made slightly oval at corners but that is negligible!

Mass moment of inertia-centroidal, $Iyo_1 = 1/6\ m\ a^2 = 1/6 \text{ x } 0.0088 \text{ x } (1/12)^2 =$ 0.00001 (slug-ft^2)

Mass moment of inertia with respect to 'z' (FW) axis, $Izo_1 = Iy_1 + m(1.25/12)^2 =$ $0.00001 + 0.0088 \text{ x x } (1.25/12)^2= 0.000106$ (slug-ft^2)

Then 4 openings have negative mass moment of inertia, $Izo = 4 \text{ x } 0.000106 =$ 0.00042 (slug-ft^2)

Wheel/Disk with 4 openings has mass moment of inertia,

$Id = Iz - Izo = 0.06 - 0.00042 = 0.0596$ (slug-ft^2)

Piston/Steel (p/s), Slender Rod

Diameter, d = 0.5"; r = 0.25"; Length, l = 4"; Actual is 5" but 1" of it is treaded and screwed into a sphere therefore only 4" length is used to calculate this rod mass moment of inertia.

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Weight, $W = r^2\pi\ l\delta = 0.25^2 \times \pi \times (4/12) \times 490 = 0.223$ (lbs); Mass m (rod) = W/g = $0.223/32.2 = 0.0069$ (slug)

$I_{yp1} = \frac{1}{2}m\ (3r^2 + l^2) = \frac{1}{2} \times 0.0069 \times (3 \times 0.25/12 + 4^2/12^2) = 0.0006$ (slug-ft²)

Rod center is 3" from axis 'z' initially, then;

$I_{yi} = I_{yp1} + m\ (3/12)^2 = 0.0006 + 0.0069 \times (3/12)^2 = 0.00103$ (slug-ft²)

The rod is moving outward, during rotation, to 5" final from 'z' axis (there is a stop pin), then

$I_{yf} = I_{yp1} + m\ (5/12)^2 = 0.0006 + 0.0069 \times (5/12)^2 = 0.0018$ (slug-ft²)

There are 4 rods.

Initial centroid of the Sphere/Rod (s/r) Assembly (From 'z' axis);

$x_1 = (0.124 \times 6.5" + 0.0069 \times 3")/(0.124 + 0.0069) = 6.32" = 0.53$ ft.

Sphere/Rod assembly mass moment of inertia; $I_{s/r} = I_o + I_{y1} = 0.000775 + 0.0006 = 0.00137$ (slug-ft²)

Initial Mass Moment Of Inertia Of S/R (Point-1);

$I_{s/ri} = I_{s/r} + (m_o + m_r)\ x_1^2 = 0.00137 + (0.124 + 0.0069) \times 0.53^2 = 0.038$ (slug-ft²)

For 4 s/r; $I_{s/ri} = 4 \times 0.038 = 0.152$ (slug-ft²)

Final Mass Moment Of Inertia Of S/R (Point-2);

S/R Assembly is moving outward to final (Point-2) position;

Final centroid of S/R Assembly from 'z' axis; $x2 = 0.53' + (2"/12)' = 0.7$ ft.

Then final (Point-2) s/r mass moment of inertia;

$I_{s/rf} = I_{s/r} + (m_o + m_r)\ x2^2 = 0.00137 + (0.124 + 0.0069) \times 0.7^2 = 0.0655$ (slug-ft²)

For 4-S/R; $I_{s/rf} = 4 \times 0.0655 = 0.262$ (slug-ft²)

Initial mass moment of inertia of 'FW' (Point-1):

$I_i = I_{s/ri} + I_d = 0.152 + 0.0596 = 0.2116$ (slug-ft²)

Final mass moment of inertia of 'FW' (Point-2):

$I_f = I_s/r_f + I_d = 0.262 + 0.0596 = 0.3216$ (slug-ft^2)

Energy Conservation

After initial spin no external moments act on the system (fw) hence there is conservation of angular momentum, and then

$I_i \times \omega_i = I_f \times \omega_f$

Initial angular momentum (Point-1) when 'fw' rotates at 52 (rad/sec) or 496 rpm is $I_i \times \omega_i = 0.2116 \times 52 = 11.0$ (lbs-s-ft)

Then from final angular momentum (Point-2), $\omega_f = I_i \times \omega_i / I_f = 11.0 / 0.3216 = 34.2$ (rad/sec) or 327 rpm.

Centrifugal Forces

$\Sigma F_n = m a_n$ (lbs); $a_n = \check{r}\,\omega^2$

One sphere/rod assembly: $F_{s/r} = m a_n = m\check{r}\,\omega^2$ (lbs),

where $m = m_s + m_r = 0.124 + 0.0069 = 0.1309$ slug.

At point #1 (Initial); $r_1 = 0.53$Ft & $\omega_i = 52$ (rad/s) then, $F_{s/r_i} = 0.1309 \times 0.53 \times 52^2 = 187.6$ (lbs),

For four assemblies: 750.4 (lbs)

At point #2 (Final); $r_2 = 0.7$Ft & $\omega_f = 34.2$ (rad/s) then, $F_{s/r_f} = 0.1309 \times 0.7 \times 34.2^2 = 107.2$ (lbs),

For four assemblies: 428.8 (lbs)

These forces will transfer vertically by steel cables to an extension spring.

Required an extension spring to balance out this force while extended 2".

Tangential Forces

$\Sigma F_t = m\check{r}\,\alpha$

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Only tangential forces acting on ‘fw’ are frictional in bearings and air friction. Calculation of these is complex and would take lot of space so I skip it for now.

$\Sigma M_O = I\alpha$ (about mass center and axis ‘z’ of rotation.)

Flywheel rotates in horizontal plane therefore g-force acts normally to horizontal plane.

Kinetic Energy

At point#1, $T1 = \frac{1}{2} I_i \omega_i^2 = \frac{1}{2} x 0.2116 x 52^2 = 286.1$ (lbs-ft), stored energy initially.

At point#2, $T2 = \frac{1}{2} I_f \omega_f^2 = \frac{1}{2} x 0.3216 x 34.2^2 = 188.1$ (lbs-ft), stored energy decreased, at final point (spheres are farthest from ‘z’ axis), since rotation decreased. Spheres are being retracted because of decreased centrifugal forces. Now starts recovery of kinetic energy since rotation increases!

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